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DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

INFORMATION CIRCULAR

# REDUCING ACCIDENTS FROM FALLS OF ROOF IN COAL MINES

PART I - SIX ESSENTIALS FOR MINE ROOF SUPPORT
BY - J. W. PAUL

PART II - METHODS AND IMPORTANCE OF ROOF TESTING
BY - H. TOMLINSON

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BY - C. W. OWINGS

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# REDUCING ACCIDENTS FROM FALLS OF ROOF IN COAL MINES[1]

## Part I. Six Essentials for Mine Roof Support

By J. W. Paul[2]

## INTRODUCTION

The material that composes the roof in coal mines differs in strength according to variations in its physical nature and characteristics. Some material such as limestone and massive sandstone (free from slips) and carbonaceous shale or bone, will often remain in place in narrow work without the use of timber or other means of support, but in wide places the use of supports becomes a real necessity. Roof material composed of shale, fire clay or small laminations of sandstone, or shale or sandstone interspersed with laminations of thin coal, presents conditions that call for timber support in both narrow and wide work. However, in narrow work such unstable roof material may be taken down until the strata assume an arch that is self-supporting for overlying firm strata such as a roof coal, a tough weather-resisting shale, sandstone, or limestone.

The proper support of the roof in roadways used for haulage or travel adds to the economy of operation by preventing delays in transportation and increases the safety of those who travel these roadways.

Roof material that is prone to fall should either be taken down promptly or immediately given support by adequate timbering.

The owner or operator of mines is presumed to furnish the timber, cap pieces and wedges that are necessary for use and to be placed near the point where they are to be used. (This is essentially the requirement of all State mining laws.)

The general practice in bituminous mines is for the operator to employ timbermen to look after the support of the roof along all haulage and traveling roads; in the rooms and at faces of entries the miner is assigned the duty of setting the props. In modified methods of mining and in concentrated practice, the timbering in all parts of the mine is frequently done by special timbermen or crews.

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2 - Senior mining engineer, U. S. Bureau of Mines, Pittsburgh Experiment Station, Pittsburgh, Pa.



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It has been found that in certain coal mines little attention has been given to regulations for timbering; in others the matter has been fully considered; observations made at the latter mines have prompted the presentation of the following six essentials for mine-roof support in the interest of the former. In any scheme for protection against roof hazards there must be:

1. Some definite system of setting timber;
2. Diagrams showing how and where to set the timber;
3. Instructions given the miners;
4. Supervision and regular inspection;
5. A record kept of any neglect to set timber; and,
6. A penalty for neglect to observe the timber regulations.

1. System of timbering. The system adopted must be chosen with reference to the need for supporting the roof; the need for this support is determined by a study of the roof material and its tendency to fall if not supported by timber. In some mines it is found that no timber is required on narrow entries because the roof remains sound without timber supports; at places where it is unsound the loose material is taken down or such timber support is placed to make it secure as is deemed necessary by an experienced mine foreman or timber boss. There are some mine roofs which will not remain in place without timber or other means of support. In all mines some definite method of roof support should be adopted, after an intensive study of the roof conditions has been made; this is a duty that devolves on the underground manager or superintendent. The method adopted should have the approval of the State mine inspector. There is a certain economic pressure in mining that calls for an unobstructed right-of-way along haulage roads to insure no delay in transportation.

2. Diagrams showing where to set timber. A study of the roof and the way in which it is influenced by the mining method used will enable a practical mine official to determine what should be the minimum requirements in the setting of timber, the distance between props, the number of rows of props, and whether crossbars are needed. In the immediate vicinity of the place where a miner is at work he should be protected from falls of the roof by posts set against the roof, the number depending on the character of the roof.

When the minimum requirements have been decided upon, a diagram showing the relative positions of the posts and the working face should be prepared; this should be placed on a bulletin board near the entrance to the mine in plain view of the miners, also at various places within the mine.

3. Instruction of miners. Each miner should be personally instructed by one of the underground officials in the setting of props for support of the roof in accordance with the regulations adopted; the miner should be cautioned to add additional posts when in doubt about the safety of the roof, and in all cases to take down, by the use of a bar, all loose roof material. The men at the face should be instructed in the method of testing the roof by the use of iron bars and, at the same time, holding the fingers of a bare hand against the roof being tested. This is known as the vibration method, and is more to be depended upon than sound alone.



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4. Supervision and inspection. The greatest guarantee against the probability of accidents by falls of roof or coal is efficient supervision and inspection by a competent underground official who believes in strict adherence to the regulations adopted for the support of the roof. The supervising official must make his visits to each man at such intervals as will assure him that the work is being conducted in accordance with the regulations and with such verbal instructions as the official may have given. Where a workman is found under dangerous roof the official should remain to see the place made safe, or he should withdraw the man from the place.

5. Record of neglect. There is no more effective practice than that of keeping a daily record of the inspections made of each working place and recording any neglect on the part of the workman to support the roof properly. In this manner the indifferent or careless workman may be identified, and can be given special instructions and supervisions if he is retained in his employment.

6. Penalty for neglect. Where timber regulations are neglected, the careless workman is liable to be injured or killed, and the operator must defray the cost of compensation as well as incur the stigma of being charged with the loss of a life. There should be some schedule of penalties for those who are found to be negligent of their own safety in failing to observe or comply with the timber regulations; these penalties should apply not only to the workman but also to the supervising official who condones violations of the regulations.

## SUMMARY

1. In any coal mine there should be some definite system for setting timber, since such a system is in the interest of economy in operation and of safety to the workmen.

2. The adoption of diagrams for the use of underground officials and miners is a great aid in promoting regularity in setting timber.

3. With a definite system and diagrams illustrating the manner of placing timber, the instructions of miners by the underground officials is more easily accomplished, and uniform practice is made possible.

4. Rigid inspection and close supervision are most essential to establishing methods which have to do with support of mine roof.

5. The use of timber or other forms of roof support if not properly set may be the cause of roof failure and a record should be kept as to the manner in which timber regulations are executed or neglected.

6. Without a plan or a scheme for the accomplishment of a definite course of action, there can be little or no discipline; and to enforce discipline there must be some penalty for neglect to follow instructions as set forth in the plan or scheme - in this case systematic timbering.



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## RECOMMENDATION

Where a plan of action has been adopted for roof support as a means of protection against accidents from falls of roof, it is recommended that a trained & experienced section or face boss be employed for each section of the mine to observe the roof constantly, to persistently point out to the miner, in his working place, all roof dangers, to give instructions as to how to safeguard the men from the dangers, and to see that his instructions are promptly carried out.



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## Part II. Methods and Importance of Roof Testing.

By H. Tomlinson[3]

### INTRODUCTION

The concluding sentence of reports on mine accidents, especially those from falls of roof and coal, frequently reads "this accident is classed as unavoidable." In reality, it could probably be shown that if the roof had been tested by a reliable method the loose rock or coal would have been detected; and if the loose material had been taken down or securely timbered, a life probably would have been saved. If the same time were spent in planning and rigidly enforcing rules and methods of roof testing and care of roof as is now spent in seeking to place the responsibility on the victim when an accident occurs, the cause of the accident in a majority of cases now reported would be eliminated and many lives and much money paid on compensation claims would be saved.

### TESTING ROOF

To test the roof properly in a working place comes as natural to a good miner as it does to the driver of an automobile to place his foot on the accelerator; to handle his automobile safely the driver had first to receive instructions from a competent driver. This is also true of a competent coal miner, who rarely gets injured from a fall of roof or coal. However, there are many coal miners in the coal mines today who have not received any training in how to care for the roof or how to test it properly.

This fact is brought to mind clearly in considering European mines, where the longwall method of mining, with its roof control problems, is used. The roof must be tested every few minutes during the shift, and yet, in comparison with the number of men employed at the working faces, the accident records from falls of roof and coal are much lower than ours.

### SOUNDING THE ROOF

After observing thousands of coal miners at work the opinion of the writer of this circular is that many underground workers do not know how to test the roof to determine its safe or unsafe condition. The general method of testing

3 - Associate mining engineer, U. S. Bureau of Mines, Pittsburgh Experiment Station, Pittsburgh, Pa.



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the roof is to "sound" it by striking it with a bar, either wooden or iron or perhaps with an iron tip, and with a miner's pick. The character of the sound is an indication of the stability of the roof. If the sound is hollow or "drummy" the roof is probably loose and dangerous; it should then be taken down or supported with timbers. If a drummy sound is not noted that does not indicate that the roof is safe, for if a dangerous piece of roof is large, it frequently does not give off hollow sounds that may be detected by the ear.

## VIBRATION TEST

Inasmuch as the character of the roof can not always be determined by sounding, a more reliable method should be used. The vibration method, which has been found to be more dependable than sounding and is applicable to coal beds less than 8 feet thick, consists of placing the bare fingers of one hand lightly against the roof and with the free hand striking the roof sharply but lightly with an iron or steel bar. The vibration of the roof against the fingers indicates the condition of the roof. In coal beds 8 to 12 feet thick, a rod held in the bare hand against the roof may be used to detect the vibrations.

## SOME ROOFS DO NOT GIVE INDICATIONS

Undoubtedly there are certain types of roof whose soundness or looseness can not be determined by sounding or by the vibration method of testing. The roof may have slip planes or cracks, "Kettle bottoms" or fossil stumps, inverted "horsebacks," and clay veins. The presence of slip planes and fossil stumps may be hidden by a thin layer of coal. Testing the roof or coal may fail to reveal the presence of these slips, cracks, and unusual conditions, so that even testing is not always effective. Wherever the condition of the roof is doubtful, systematic timbering should be used. If a coal bed or a section of a bed is known to have unsafe roof conditions, a definite system of timbering should be used in addition to testing the roof. From 85 to 90 per cent of roof-fall accidents occur at or near working faces; however, the other 10 or 15 per cent of the accidents occur along haulage roads, air courses, and similar passageways. Therefore, it is necessary to make roof testing sufficiently extensive to include all open sections of the mine through which men may be required to pass. This phase of testing is a part of the routine work of mine officials and as such is included under supervision.

The vibration method of testing roof should be employed, and rules should be adopted by all operating companies to provide that the roof and sides of working places shall be tested by the workmen when they go on shift, immediately after firing any shots, when a supervising official makes his visits, and at intervals not exceeding two hours during the shift.

The adoption of this rule, and its thorough enforcement would be a great factor in preventing accidents from falls of roof and coal.

## SUPERVISION

Adequate supervision is important in preventing accidents from falls of roof and coal and in the economical operation of a mine.



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The mine should be so divided into districts that a supervising official can visit each working face three to four times during the shift, in order to properly supervise and instruct the men in his district in their work.

Many of the workmen who become miners are "wedded to the mine" after a few months experience and like their work and surrounding conditions; but there are others who enter upon mine work because no other employment is available and continue in the mine only until they find employment in other industries that suit their choice. The workman who adopts the mine for his life work is amenable to discipline and may be taught to exercise proper care for his safety, whereas the workman who takes a miner's job as temporary employment until something more attractive "turns up," is not vitally concerned with learning the tricks of the trade and becomes a liability to his employer in the matter of an accident-prevention program. Many experienced miners become hardened to the hazards surrounding their work and often take chances that offer a serious risk, and the inexperienced often take chances without realizing the seriousness of the risk; therefore, with this condition in mind, it is essential that there be efficient supervision to insure that the workmen follow instructions and regulations for their protection against accidents from falls of roof.

Each supervising official should be required to carry a tool for the purpose of testing the roof in each working place visited. He should also know definitely what to examine in each place, such as the roof, posting, standing coal, manner of securing the car, placement of shots, and quality of production.

A point in the mining law of many coal mining States that is usually overlooked is that the mine foreman or any supervisory assistant of the foreman is responsible for the safe condition of the roof on entries and the roadway in rooms as well as at the working face. It is indeed rare to observe a mine official testing the roof except at or near the working face. All parts of the mine traveled by men should have the roof tested every day and in the places where men are working the roof should be tested at least every two hours.

An important provision of some mining laws is the requirement that a mine foreman who discovers a dangerous condition shall remain at such point of danger until the place is made safe or shall require the workman to vacate the place until it is made safe. This requirement is an integral part of the practice of testing the roof and coal to determine the danger from probable falls and to make the place safe by taking down the dangerous material or promptly timbering it.

## SYSTEMATIC METHOD OF ROOF SUPPORT

A definite method of roof support should be adopted that will fit the condition of the individual mine and provide a maximum distance between supports. Where a systematic method is used it is only necessary for the miner to rely on his own judgment when special conditions arise.

A large-sized cap piece placed at right angles with the roof slips should be used on all posts.

A systematic method of applying spragg or leaners should be adopted for all overhanging coal while the faces are being cut by mining machines.



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## Part III. Accidents in Coal Mines Due to Falls of Roof

By C. W. Owings[4]

### INTRODUCTION

The adage "to be forewarned is to be forearmed" applies directly to the prevention or reduction of fall-of-roof accidents in coal mines; "to be forewarned" may be considered as the result of frequent testing of the roof, and "to be forearmed" may well be taken to mean systematic timbering of the roof in coal mines. A common expression among mining men is "if the roof is loose (Presupposing testing of the roof), take it down; if loose material can not be taken down or if the condition of the roof is doubtful, timber it." While this rule of making the roof condition safe is generally known, testing and timbering of the roof are generally disregarded or imperfectly practiced in many mines, as is indicated by the large number of fatal accidents reported each year from falls of roof.

### STATISTICS

During the 10-year period 1919 to 1928, inclusive, 8,909 fatal accidents (or 49.48 per cent of all accidents) in bituminous coal mines of the United States were caused by falls of roof and coal.[5] During the five-year period 1924 to 1928, inclusive, in bituminous coal mines 4,495 fatal accidents of 8,578 underground accidents, or 52.5 per cent, resulted from falls of roof and coal. During the same five-year period, 5,569 of a total of 10,808 underground fatalities, or 52.1 per cent of all underground accidents, were caused by falls of roof and coal in anthracite and bituminous mines.

This record is not one of which to be proud; the fact that nearly three persons are killed by fall of roof and coal for every fatality from underground haulage and that the ratio of fatalities by falls to those from explosions of gas or coal-dust is about 4 to 1, should serve as an indictment against the apparent indifference of many of our mining men toward the taking of definite adequate measures to prevent accidents from falls of roof and coal. It is true that in 1928 there was a decrease in the number killed as compared with the records for 1925, 1926, and 1927, but there has been no appreciable decrease in number of killed during the 10-year period 1919 to 1928, inclusive as shown in Table 1.

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4 - Associate engineer, U. S. Bureau of Mines.

5 - Adams, W. W., Coal Mine Fatalities in the United States; 1927. Bull. 293, Bureau of Mines, 1928, 120 pp. Coal Mine Fatalities No. C. M. F. 84, Coal Mine Fatalities in January, 1929.



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Table 1.- Coal-mine fatalities during the years 1919 to 1928 from falls of roof and coal

| Year | Number killed | Year | Number killed |
|---|---|---|---|
| 1919 | 1100 | 1924 | 1062 |
| 1920 | 1132 | 1925 | 1080 |
| 1921 | 1024 | 1926 | 1214 |
| 1922 | 905 | 1927 | 1149 |
| 1923 | 1167 | 1928 | 1064 |

A study of these figures shows the need of putting forth a systematic effort to reduce and possibly eliminate this major cause of accidents in coal mines. Any concerted effort to eliminate this cause must embrace frequent and effective testing of roof and coal, also systematic timbering supplemented with additional timbering as conditions demand.

## SPECIFIC CASES AND REMEDIES

A recent fatality was the result of depending too much on sound to detect loose roof. The coal bed was about 12 feet thick and the roof had a number of slips, some of which were invisible and ran at an an angle of about 45° to the center line of the room. The timber in the place consisted of round posts surmounted by cap pieces 2 by 5 by 20 inches. The posts were 6 feet 4 inches apart, and according to the testimony of a number of mine officials and workmen the place was properly timbered. The pillar was being drawn in this room, and as several falls had been made, there was danger of roof falls, although the roof was considered "good." The fireboss and the safety inspector had each made two inspections of the place, and the assistant foreman had inspected it about an hour before the accident, testing the roof with a wooden tamping bar by the "sound" method. The miner who was killed had also tested the piece of rock about 30 minutes before the accident, also using a tamping bar and sounding the roof. While loading a car a piece of rock 8 by 4 feet by 9 inches fell, inflicting injuries from which the miner died in about three hours.

If the officials had used the sounding rods provided by the company for detection of roof vibration, or if the miner had used the vibration method of testing, the loose condition of the roof might have been detected and the accident averted.

The lesson to be learned from this accident is that the loose character of large pieces of rock or coal can not always be detected, hence the "sounding" method is not always reliable. Another point to be observed is that in places where slips are known to exist in the roof the use of large cap pieces or collars supported by several props is advisable and if pillars are being extracted, posts set 6 feet or more apart do not afford proper protection.

Even where the roof is sounded and found to be unsafe, no benefit will be derived from this safety practice unless adequate precautions are taken to prevent the workman from being caught by the roof if it falls. An account of an accident in a West Virginia mine shows the futility of taking a chance. A timberman had "sounded" the roof and knew it to be unsafe; however, he believed that he would have time to set a crossbar before the slate could fall. While digging



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a hole to set the crossbar a loose piece of slate weighing about 75 pounds fell and struck him on the head, killing him instantly. The lessons to be learned from this accident are that certain types of loose roof may be detected by sounding; that when loose roof is detected no one should work under it; and that if the roof is loose enough to fall, it is far better to pull down all loose material rather than attempt to timber it.

Another accident reported to the United States Bureau of Mines indicates the shortcomings of the sound method and illustrates the possibilities of the vibration method for testing coal-mine roof: In a Virginia mine the practice was to lay the haulage track in the center of rooms and set posts on only one side of the track. When the pillars were being drawn, after a mining machine had cut a slab about 50 feet long, the track was shifted to the rib. About 8 o'clock one morning the mine foreman visited a room which was having the first slab undercut. He examined the place, presumably testing the roof by sounding, pronounced it to be safe and continued with his inspection of the mine. About half an hour later a piece of roof 50 by 14 by 2 feet fell from the unsupported roof at the place being undercut. Five men were caught under the heavy piece of rock and killed instantly. While the practice of leaving such a large area of roof unsupported in pillar extraction may have been considered safe as the result of a sound test, nevertheless if the vibration method of testing the roof had been used, the dangerous character of the rock undoubtedly would have been detected. In all events, such a large area should have had some timber support even though the test indicated the roof to be sound.

The value of testing the roof by the vibration method is indicated in the following account of a roof-fall accident:

In a pillar section of a mine operating in the Pittsburgh coal bed about 10 men were congregated at a point about 30 feet outby the breakline of a chain pillar. The general method of testing was to sound the roof, and the official in charge had, so he stated, tested the roof at the start of the shift. About an hour later while these 10 men were talking, one of them placed the fingers of one hand against the roof and then struck the roof a blow with a pick held in his other hand. Immediately he felt a pronounced vibration which startled him and he gave a cry of warning. All of the men jumped, and, with the exception of one man, they escaped; a piece of rock 20 by 6 by 2 feet fell and crushed out the life of one man. It seems probable that if the mine foreman had tested the roof by the vibration method its unstable condition would have been detected and a life would have been saved.

A case showing the responsibility of the mine foreman or his assistant is brought out in the report of a fall-of-roof accident, quoted below:

> At the time of the accident, deceased, a driver, was waiting on miners to finish loading a car of coal when a fall of top coal and rock fell from the roof near the face and struck him, killing him instantly. The accident occurred in a chain pillar between entries and was caused by a large pot rock breaking through the top coal roof which covered the pot rock and made it invisible. The place had been visited by the fore-



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man two hours prior to the accident and found safe, although he ordered an extra crossbar put up, as he considered that the distance was too wide between the last crossbar and the face. The instructions were evidently being carried out when the accident occurred. There was no evidence of weight on any of the timbers. The accident was unforeseen and is classed as unavoidable.

The above account clearly shows that the mine foreman betrayed the trust placed in him by not staying until the crossbar was placed. Inasmuch as the accident occurred two hours after instruction had been given to set the crossbar, it is evident that if the mine foreman had remained until the timbering had been finished, the accident would not have occurred. Therefore the accident resulted from failure to observe safe practices, which are: Official remaining until the place is made safe; withdrawal of the workmen; and timbering unsafe roof.

Webster's dictionary defines supervision as the "act of overseeing; inspection"; hence it is evident that a supervisory official should be a man whose experience has trained him to be an instructor and one who observes conditions and gives orders for making the working places safe. If this attitude is observed in connection with preventing falls of roof and coal accidents there will be a great reduction in fatalities and injuries.



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By H. Tomlinson[3]

### INTRODUCTION

The concluding sentence of reports on mine accidents, especially those from falls of roof and coal, frequently reads "this accident is classed as unavoidable." In reality, it could probably be shown that if the roof had been tested by a reliable method the loose rock or coal would have been detected; and if the loose material had been taken down or securely timbered, a life probably would have been saved. If the same time were spent in planning and rigidly enforcing rules and methods of roof testing and care of roof as is now spent in seeking to place the responsibility on the victim when an accident occurs, the cause of the accident in a majority of cases now reported would be eliminated and many lives and much money paid on compensation claims would be saved.

### TESTING ROOF

To test the roof properly in a working place comes as natural to a good miner as it does to the driver of an automobile to place his foot on the accelerator; to handle his automobile safely the driver had first to receive instructions from a competent driver. This is also true of a competent coal miner, who rarely gets injured from a fall of roof or coal. However, there are many coal miners in the coal mines today who have not received any training in how to care for the roof or how to test it properly.

This fact is brought to mind clearly in considering European mines, where the longwall method of mining, with its roof control problems, is used. The roof must be tested every few minutes during the shift, and yet, in comparison with the number of men employed at the working faces, the accident records from falls of roof and coal are much lower than ours.

### SOUNDING THE ROOF

After observing thousands of coal miners at work the opinion of the writer of this circular is that many underground workers do not know how to test the roof to determine its safe or unsafe condition. The general method of testing

3 - Associate mining engineer, U. S. Bureau of Mines, Pittsburgh Experiment Station, Pittsburgh, Pa.



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the roof is to "sound" it by striking it with a bar, either wooden or iron or perhaps with an iron tip, and with a miner's pick, although one large coal mining company specifies that all roof testing be done with a steel bar of definite minimum weight without weld or joint. The character of the sound is an indication of the stability of the roof. If the sound is hollow or "drummy" the roof is probably loose and dangerous; it should then be taken down or supported with timbers. If a drummy sound is not noted that does not indicate that the roof is safe, for if a dangerous piece of roof is large, it frequently does not give off hollow sounds that may be detected by the ear.

## VIBRATION TEST

Inasmuch as the character of the roof can not always be determined by sounding, a more reliable method should be used. The vibration method, which has been found to be more dependable than sounding and is applicable to coal beds less than 8 feet thick, consists of placing the bare fingers of one hand lightly against the roof and with the free hand striking the roof sharply but lightly with an iron or steel bar. The vibration of the roof against the fingers indicates the condition of the roof. In coal beds 8 to 12 feet thick, a rod held in the bare hand against the roof may be used to detect the vibrations.

## SOME ROOFS DO NOT GIVE INDICATIONS

Undoubtedly there are certain types of roof whose soundness or looseness can not be determined by sounding or by the vibration method of testing. The roof may have slip planes or cracks, "Kettle bottoms" or fossil stumps, inverted "horsebacks," and clay veins. The presence of slip planes and fossil stumps may be hidden by a thin layer of coal. Testing the roof or coal may fail to reveal the presence of these slips, cracks, and unusual conditions, so that even testing it not always effective. Wherever the condition of the roof is doubtful, systematic timbering should be used. If a coal bed or a section of a bed is known to have unsafe roof conditions, a definite system of timbering should be used in addition to testing the roof. From 85 to 90 per cent of roof-fall accidents occur at or near working faces; however, the other 10 or 15 per cent of the accidents occur along haulage roads, air courses, and similar passageways. Therefore, it is necessary to make roof testing sufficiently extensive to include all open sections of the mine through which men may be required to pass. This phase of testing is a part of the routine work of mine officials and as such is included under supervision.

The vibration method of testing roof should be employed, and rules should be adopted by all operating companies to provide that the roof and sides of working places shall be tested by the workmen when they go on shift, immediately after firing any shots, when a supervising official makes his visits, and at intervals not exceeding two hours during the shift.

The adoption of this rule, and its thorough enforcement would be a great factor in preventing accidents from falls of roof and coal.

## SUPERVISION

Adequate supervision is important in preventing accidents from falls of roof and coal and in the economical operation of a mine.



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The mine should be so divided into districts that a supervising official can visit each working face three to four times during the shift, in order to properly supervise and instruct the men in his district in their work.

Many of the workmen who become miners are "wedded to the mine" after a few months experience and like their work and surrounding conditions; but there are others who enter upon mine work because no other employment is available and continue in the mine only until they find employment in other industries that suit their choice. The workman who adopts the mine for his life work is amenable to discipline and may be taught to exercise proper care for his safety, whereas the workman who takes a miner's job as temporary employment until something more attractive "turns up," is not vitally concerned with learning the tricks of the trade and becomes a liability to his employer in the matter of an accident-prevention program. Many experienced miners become hardened to the hazards surrounding their work and often take chances that offer a serious risk, and the inexperienced often take chances without realizing the seriousness of the risk; therefore, with this condition in mind, it is essential that there be efficient supervision to insure that the workmen follow instructions and regulations for their protection against accidents from falls of roof.

Each supervising official should be required to carry a tool for the purpose of testing the roof in each working place visited. He should also know definitely what to examine in each place, such as the roof, posting, standing coal, manner of securing the car, placement of shots, and quality of production.

A point in the mining law of many coal mining States that is usually overlooked is that the mine foreman or any supervisory assistant of the foreman is responsible for the safe condition of the roof on entries and the roadway in rooms as well as at the working face. It is indeed rare to observe a mine official testing the roof except at or near the working face. All parts of the mine traveled by men should have the roof tested every day and in the places where men are working the roof should be tested at least every two hours.

An important provision of some mining laws is the requirement that a mine foreman who discovers a dangerous condition shall remain at such point of danger until the place is made safe or shall require the workman to vacate the place until it is made safe. This requirement is an integral part of the practice of testing the roof and coal to determine the danger from probable falls and to make the place safe by taking down the dangerous material or promptly timbering it.

## SYSTEMATIC METHOD OF ROOF SUPPORT

A definite method of roof support should be adopted that will fit the condition of the individual mine and provide a maximum distance between supports. Where a systematic method is used it is only necessary for the miner to rely on his own judgment when special conditions arise.

A large-sized cap piece placed at right angles with the roof slips should be used on all posts.

A systematic method of applying sprags or leaners should be adopted for all overhanging coal while the faces are being cut by mining machines.



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The following instructions for testing roof, as issued by the general manager of a large coal mining company, are concise and contain much valuable information.

TO ALL COLLIERY SUPERINTENDENTS:

Please impress on all your underground officials the necessity of their seeing that these instructions are carried out and that the men under them are provided with necessary equipment.

Lay particular stress on the necessity of their explaining to the miners why we want each working place equipped with a special implement for the testing of roof. The reason is that having such a tool the miner will not be tempted to use an improper apparatus such as a copper-headed drill or a part of his drilling machine with mechanical attachments or a bar of steel too light in weight.

HOW TO TEST THE ROOF

The test shall be made by the miner standing in such a position that he can place the fingers of one hand on the roof so as to feel the vibration caused by lightly bumping the roof rock with a steel bar. This bar shall be heavy enough to give a decided "thump" but not so heavy as to be unwieldy. Its length will be regulated by the thickness of the bed, as mentioned later.

WHEN TO TEST THE ROOF

Each miner shall test the roof of his working place immediately he enters it to begin his shift and shall test again after the firing of each blast and as often in addition as is necessary to make sure of the safety of the working place.

EQUIPMENT FOR TESTING

Each miner should provide himself for testing purposes, with a solid steel bar. We insist upon a solid bar, without attachments or welds, in order to guard absolutely against misinterpretation of sound due to vibration of the bar itself.

INTERPRETATION OF TEST

Each miner must be instructed by the sectional foreman as to the necessity of using while testing the roof, not only his senses of sight and sound but the sense of touch. A test of each individual must be carried out by this sectional foreman to determine whether that individual properly interprets the vibrations which are received through the fingers when a piece of loose roof is lightly rapped. This test must also include a determination as to whether each individual properly interprets the different sounds which are given off by loose roof and by solid roof when tapped.

WHAT TO DO AFTER TESTING

Each individual must be made to understand that when the test indicates that the roof is of questionable character, he must make the place safe,



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preferably by taking down the loose rock. If this is not possible he may properly support the loose rock with props or cross timbers.

TESTING ROOF OVER
12 FEET IN HEIGHT

The miner must be provided with a horse or horses of sufficient height and plank of sufficient length so that he can erect a scaffold from which to get into the proper position to test the roof in accordance with the above instructions. In exceptionally high places special arrangements will have to be made for erecting scaffolds and for cooperation between miners in adjacent chambers when roof is to be tested. The miner should provide himself with a solid steel testing bar weighing not less than 15 pounds (1" diameter by 6' long weighs 15 3/4 pounds).

TESTING ROOF 7 TO
12 FEET IN HEIGHT

The miner must be provided with a small horse or horses and plank so as to be able to get into a position that will enable him to test the roof in accordance with the above instructions. He should be provided with a solid steel testing bar weighing not less than 15 pounds (1" diameter by 6' long weighs 15 3/4 pounds).

TESTING ROOF UNDER
7 FEET IN HEIGHT

The miner should be provided with a solid steel testing bar weighing not less than 12 pounds. The length of this bar will vary with the thickness of the seam. It should be about six inches shorter than the thickness of the seam.

The following sizes are suitable for the bed thicknesses noted:

| | Diameter | Length | Weight | Price |
|---|---|---|---|---|
| 6½ ft. and over | 1" | 6' | 15½ lb. | $0.99 |
| 5½ ft. to 6½ ft. | 1" | 5' | 13 " | 0.65 |
| 4½ ft. to 5½ ft. | 1" | 4' | 10 " | 0.40 |
| 3½ ft. to 4½ ft. | 1¼" | 3' | 12½ " | 0.50 |
| 2½ ft. to 3½ ft. | 1¼" | 2' | 12 " | 0.48 |
| Under 2 ft. | 1¼" | 18" | 9 " | 0.36 |

TESTING ROOF WITH HAMMER

This practice is dangerous if the man stands immediately beneath the roof he is testing, but is sometimes advantageous in detecting a large bell or slab. It is therefore to be discouraged unless the man using this method shows by his actions that he is aware of the possible danger. If any individual prefers to use this method the sectional foreman must make sure that the miner keeps out from under the piece he is testing. The foreman should endeavor to persuade the miner who uses the hammer method to also provide himself with the proper size of testing bar.



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## Part III. Accidents in Coal Mines Due to Falls of Roof

By C. W. Owings[4]

### INTRODUCTION

The adage "to be forewarned is to be forearmed" applies directly to the prevention or reduction of fall-of-roof accidents in coal mines; "to be forewarned" may be considered as the result of frequent testing of the roof, and "to be forearmed" may well be taken to mean systematic timbering of the roof in coal mines. A common expression among mining men is "if the roof is loose (Presupposing testing of the roof), take it down; if loose material can not be taken down or if the condition of the roof is doubtful, timber it." While this rule of making the roof condition safe is generally known, testing and timbering of the roof are generally disregarded or imperfectly practiced in many mines, as is indicated by the large number of fatal accidents reported each year from falls of roof.

### STATISTICS

During the 10-year period 1919 to 1928, inclusive, 8,909 fatal accidents (or 49.49 per cent of all accidents) in bituminous coal mines of the United States were caused by falls of roof and coal.[5] During the five-year period 1924 to 1928, inclusive, in bituminous coal mines 4,495 fatal accidents of 8,578 underground accidents, or 52.5 per cent, resulted from falls of roof and coal. During the same five-year period, 5,569 of a total of 10,808 underground fatalities, or 52.1 per cent of all underground accidents, were caused by falls of roof and coal in anthracite and bituminous mines.

This record is not one of which to be proud; the fact that nearly three persons are killed by fall of roof and coal for every fatality from underground haulage and that the ratio of fatalities by falls to those from explosions of gas or coal-dust is about 4 to 1, should serve as an indictment against the apparent indifference of many of our mining men toward the taking of definite adequate measures to prevent accidents from falls of roof and coal. It is true that in 1928 there was a decrease in the number killed as compared with the records for 1925, 1926, and 1927, but there has been no appreciable decrease in number of killed during the 10-year period 1919 to 1928, inclusive as shown in Table 1.

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4 - Associate engineer, U. S. Bureau of Mines.

5 - Adams, W. W., Coal Mine Fatalities in the United States; 1927. Bull. 293, Bureau of Mines, 1928, 120 pp. Coal Mine Fatalities No. C. M. F. 84, Coal Mine Fatalities in January, 1929.



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Table 1.- Coal-mine fatalities during the years 1919 to 1928 from falls of roof and coal

| Year | Number killed | Year | Number killed |
|---|---|---|---|
| 1919 | 1100 | 1924 | 1082 |
| 1920 | 1132 | 1925 | 1080 |
| 1921 | 1024 | 1926 | 1214 |
| 1922 | 905 | 1927 | 1149 |
| 1923 | 1167 | 1928 | 1064 |

A study of these figures shows the need of putting forth a systematic effort to reduce and possibly eliminate this major cause of accidents in coal mines. Any concerted effort to eliminate this cause must embrace frequent and effective testing of roof and coal, also systematic timbering supplemented with additional timbering as conditions demand.

## SPECIFIC CASES AND REMEDIES

A recent fatality was the result of depending too much on sound to detect loose roof. The coal bed was about 12 feet thick and the roof had a number of slips, some of which were invisible and ran at an an angle of about 45° to the center line of the room. The timber in the place consisted of round posts surmounted by cap pieces 2 by 5 by 20 inches. The posts were 6 feet 4 inches apart, and according to the testimony of a number of mine officials and workmen the place was properly timbered. The pillar was being drawn in this room, and as several falls had been made, there was danger of roof falls, although the roof was considered "good." The fireboss and the safety inspector had each made two inspections of the place, and the assistant foreman had inspected it about an hour before the accident, testing the roof with a wooden tamping bar by the "sound" method. The miner who was killed had also tested the piece of rock about 30 minutes before the accident, also using a tamping bar and sounding the roof. While loading a car a piece of rock 8 by 4 feet by 9 inches fell, inflicting injuries from which the miner died in about three hours.

If the officials had used the sounding rods provided by the company for detection of roof vibration, or if the miner had used the vibration method of testing, the loose condition of the roof might have been detected and the accident averted.

The lesson to be learned from this accident is that the loose character of large pieces of rock or coal can not always be detected, hence the "sounding" method is not always reliable. Another point to be observed is that in places where slips are known to exist in the roof the use of large cap pieces or collars supported by several props is advisable and if pillars are being extracted, posts set 6 feet or more apart do not afford proper protection.

Even where the roof is sounded and found to be unsafe, no benefit will be derived from this safety practice unless adequate precautions are taken to prevent the workman from being caught by the roof if it falls. An account of an accident in a West Virginia mine shows the futility of taking a chance. A timberman had "sounded" the roof and knew it to be unsafe; however, he believed that he would have time to set a crossbar before the slate could fall. While digging



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a hole to set the crossbar a loose piece of slate weighing about 75 pounds fell and struck him on the head, killing him instantly. The lessons to be learned from this accident are that certain types of loose roof may be detected by sounding; that when loose roof is detected no one should work under it; and that if the roof is loose enough to fall, it is far better to pull down all loose material rather than attempt to timber it.

Another accident reported to the United States Bureau of Mines indicates the shortcomings of the sound method and illustrates the possibilities of the vibration method for testing coal-mine roof: In a Virginia mine the practice was to lay the haulage track in the center of rooms and set posts on only one side of the track. When the pillars were being drawn, after a mining machine had cut a slab about 50 feet long, the track was shifted to the rib. About 8 o'clock one morning the mine foreman visited a room which was having the first slab undercut. He examined the place, presumably testing the roof by sounding, pronounced it to be safe and continued with his inspection of the mine. About half an hour later a piece of roof 50 by 14 by 2 feet fell from the unsupported roof at the place being undercut. Five men were caught under the heavy piece of rock and killed instantly. While the practice of leaving such a large area of roof unsupported in pillar extraction may have been considered safe as the result of a sound test, nevertheless if the vibration method of testing the roof had been used, the dangerous character of the rock undoubtedly would have been detected. In all events, such a large area should have had some timber support even though the test indicated the roof to be sound.

The value of testing the roof by the vibration method is indicated in the following account of a roof-fall accident:

In a pillar section of a mine operating in the Pittsburgh coal bed about 10 men were congregated at a point about 30 feet outby the breakline of a chain pillar. The general method of testing was to sound the roof, and the official in charge had, so he stated, tested the roof at the start of the shift. About an hour later while these 10 men were talking, one of them placed the fingers of one hand against the roof and then struck the roof a blow with a pick held in his other hand. Immediately he felt a pronounced vibration which startled him and he gave a cry of warning. All of the men jumped, and, with the exception of one man, they escaped; a piece of rock 20 by 6 by 2 feet fell and crushed out the life of one man. It seems probable that if the mine foreman had tested the roof by the vibration method its unstable condition would have been detected and a life would have been saved.

A case showing the responsibility of the mine foreman or his assistant is brought out in the report of a fall-of-roof accident, quoted below:

> At the time of the accident, deceased, a driver, was waiting on miners to finish loading a car of coal when a fall of top coal and rock fell from the roof near the face and struck him, killing him instantly. The accident occurred in a chain pillar between entries and was caused by a large pot rock breaking through the top coal roof which covered the pot rock and made it invisible. The place had been visited by the fore-



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man two hours prior to the accident and found safe, although he ordered an extra crossbar put up, as he considered that the distance was too wide between the last crossbar and the face. The instructions were evidently being carried out when the accident occurred. There was no evidence of weight on any of the timbers. The accident was unforeseen and is classed as unavoidable.

The above account clearly shows that the mine foreman betrayed the trust placed in him by not staying until the crossbar was placed. Inasmuch as the accident occurred two hours after instruction had been given to set the crossbar, it is evident that if the mine foreman had remained until the timbering had been finished, the accident would not have occurred. Therefore the accident resulted from failure to observe safe practices, which are: Official remaining until the place is made safe; withdrawal of the workmen; and timbering unsafe roof.

Webster's dictionary defines supervision as the "act of overseeing; inspection"; hence it is evident that a supervisory official should be a man whose experience has trained him to be an instructor and one who observes conditions and gives orders for making the working places safe. If this attitude is observed in connection with preventing falls of roof and coal accidents there will be a great reduction in fatalities and injuries.



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